State of Illinois
Department of Transportation
Division of Aeronautics

POLICY MEMORANDUM

April 1, 2010   Springfield   Number: 87-2

TO: CONSULTING ENGINEERS

SUBJECT: DENSITY ACCEPTANCE OF BITUMINOUS PAVEMENTS

1. Introduction

This Policy Memorandum deals with the implementation of the bituminous density
quality assurance specifications as outlined in the Standard Specifications for
Construction of Airports, Sections 401-4.15 and 403-4.15.

II. Sampling

After completion of compaction and when the pavement has reached ambient
temperature, the paved area shall be divided into Sublots of 500 tons per type of
mix. One core sample (2 cores per sample) shall be taken from each Sublot. The
longitudinal and transverse location for each sample shall be determined by use of
a random number "Deck" provided by the Division. No core shall be taken closer
than two (2) feet from the edge of the mat. A core extraction device shall be used
to obtain all cores from the mat. All cores are to be taken by the contractor under
the supervision and remain in the possession of the Engineer. It is imperative that
the Engineer and the contractor realize that the cores are "money" and that
improper coring, extraction, shipping and/or testing can be costly.

One mix sample per 1000 tons of mix laid shall be taken for Extraction, Maximum
Specific Gravity (G_{mm}) and Air Void tests. The mix samples shall be sampled by
the contractor and split in half.

The Resident Engineer shall randomly designate and send the split samples to an
independent laboratory for testing. The laboratory will be verified to be ASTM-
certified for all the required testing and be contracted through the Consultant. The
frequency of testing split samples shall be 1 per 5000 tons. Higher frequencies
may be necessary if the contractor's tests, and/or mix quality control are
inconsistent.

III. Testing

All cores shall be tested for Bulk Specific Gravity (G_{sb}) in accordance with ASTM D2726 using Procedure 9.1, "For Specimens That Contain Moisture". The Theoretical Maximum Gravity (G_{mm}) shall be determined according to ASTM D2041, Procedure 7. From these tests the in-place air voids of the compacted pavement are calculated according to ASTM D3203 for "dense bituminous paving mixtures". Selection of the proper G_{mm} shall be based on a running average of four (4) tests per Lot.

Eg. Lot 1 - Use the average of the two (2) tests for Lot 1.
    Lot 2 - Use the average of the four (4) tests from Lots 1 and 2.
    Lot 3 - Use the average of the four (4) tests from Lots 2 and 3.

    NOTE: When more than four (4) Sublots are used, still use a
             running average of four (4) tests per Lot.

IV. Acceptance Calculations

The first step in calculating the quantities for pay is to calculate the Mean ($\bar{x}$) and the Standard Deviation (S) of the Sublot tests. From this data the Lot samples should first be tested for outliers. After consideration for outliers, the Percent Within Tolerance (PWT) and the Percent Within Limits (PWL) are calculated to determine the final pay quantities for the Lot.

<p style="text-align:center">EXAMPLE</p>

1.   Test Data
         Lot Quantity = 2000 tons
         Sublot Test 1 = 4.35 % Air Voids
         Sublot Test 2 = 3.96 % Air Voids
         Sublot Test 3 = 6.75 % Air Voids
         Sublot Test 4 = 6.25 % Air Voids

2.   Calculating the Mean and Standard Deviation

Sublot	x	$(x - \bar{x})$	$(x - \bar{x})^2$
1	4.35	- 0.978	0.956
2	3.96	- 1.368	1.871
3	6.75	1.422	2.022
4	6.25	0.922	0.850
Sum =	21.31		5.699

N   = 4

Mean($\bar{x}$) = 21.34 / 4 = 5.328

Variance $(S)^2 = \text{Sum}\dfrac{(X - \overline{X})^2}{3} = \dfrac{5.699}{3} = 1.900$

Standard Deviation $S = \sqrt{1.900} = 1.378$

3. Test For Outliers

Check for Critical "T" Values

$T = \dfrac{|(X_1 - \overline{X})|^*}{S} = \dfrac{|3.96 - 5.328|}{1.378} = 0.99$

* Difference between the suspect test value (X_1) and the Mean ($\overline{X}$).

If the T value exceeds the critical "T" Value in the table below and no assignable cause can be determined for the outlier, discard the suspected test measurement and obtain another random sample from the Sublot in question. If the new test exceeds the Mean ($\overline{X}$) in the same direction from the Mean as the suspected test, recalculate the T value including all tests (original test, suspected test, and new test) for an outlier and for computing final payment.

TABLE OF CRITICAL "T" VALUES

Number of observations (N)	Critical "T" Value 5% Significance Level
3	1.15
4	1.46
5	1.67
6	1.82
7	1.94
8	2.03
9	2.11
10	2.18
11	2.23
12	2.29

Based on the above table, the "T" value of 0.99 does not exceed the Critical "T" Value of 1.46 for N = 4. Therefore, the value (3.96) is not an outlier and shall be used in calculating the Lot payment.

4. Calculation of Lot Payment

To calculate the Lot Payment use the Acceptance Criteria as outlined under Item 401-4.15(c) or Item 403-4.15(c).

$Q_L = \dfrac{(\overline{X} - 1)}{S} = \dfrac{5.328 - 1}{1.378} = 3.141$

$$Q_u = \left(\frac{7 - \bar{x}}{S} \right) = \frac{7 - 5.328}{1.378} = 1.213$$

From this data the Percentage Within Tolerance (PWT) for both the lower and upper tolerance limits is determined by Table 6 (see Item 401 Bituminous Surface Course and/or Item 403 Bituminous Base Course in the Standard Specifications) for the number (N) of samples tested.

Eq. PWT (lower) = 99.0%
     PWT (upper) = 90.4%

We now calculate the Percent Within Limits (PWL) for the Lot.

PWL = [PWT (lower)] + [PWT (upper)] - 100
PWL = (99.0 + 90.4) - l00 = 89.4%

Using Table 5, the % Adjustment in Lot Quantity is:

% Adjustment = 0.5 PWL + 55.0
% Adjustment = 0.5 (89.4) + 55.0
% Adjustment = 99.7

Adjusted Quantities = % Adjustment x Lot Quantities
Adjusted Quantities = 0.997 x 2000 tons
Adjusted Quantities = 1994 tons

5.   Resampling and Retesting

The contractor has the right to request the resampling and retesting of a complete Lot. This privilege is only allowed once for each Lot and must be requested in writing by the contractor within 48 hours of receiving the official report from the Engineer.

6.   Reporting

After completion of the tests for each Lot, the Engineer shall complete the necessary calculations for final adjustment in quantities on the Form AER-1 and have both the Engineer and the Contractor sign the report for copying to both the FAA and IDOA.

Steven J. Long, P.E.
Acting Chief Engineer

Supersedes Policy Memorandum 87-2, dated January 1, 2004.